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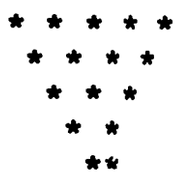
ABSTRACT

Learning Activity Packages (LAP) relating to time, space, and matter are presented for use in sampling a new type of learning for a whole year. Besides the unit on introduction to individualized learning, 11 major topics are incorporated into three other units: (1) observation of the physical world, (2) space and exploration for environmental benefit of earth, and (3) exploring the planet earth. A set of self-directed activities is given in each topic, leading the students to learn on their own and participate in class discussions. Most activities are adopted from the content of earth science textbooks, while others are in connection with selected filmstrips and science series. Excerpts concerning the importance of information gained from moon, learning from the moon, geology of Apollo 15 moon landing site, man's changing view of the earth, and keeping up to date on the moon are included along with a message to citizens of tomorrow. Pretests, self-evaluation tests, and posttests are used in evaluation. As appendices, two remedial units dealing with calculation with decimals and scientific notation of numbers are provided. (CC)

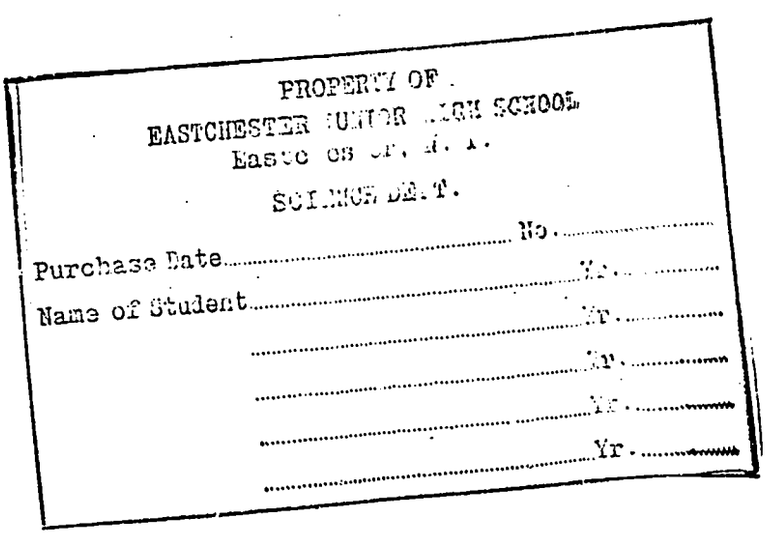
INDIVIDUALIZED INSTRUCTION IN SCIENCE

Learning Activity Packages



T.S.M.

Time, Space, Matter



Eastchester Public Schools
Eastchester, New York

R.M. Kuczma

TSM

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A MESSAGE TO OUR CITIZENS OF TOMORROW

As astronauts Armstrong, Collins, and Aldrin swept across the country following their historic mission to the Moon, the appeal was to the young people, to the New Age, the Age of Mankind, when man would look upon man as his brother. From outer space you could not see if the Earthlings were yellow, brown, red, black, or white and the continents themselves, on which the nations of the earth lived, seemed very close together. Would awakening Mankind, as one entity, develop a universal consciousness and then, a universal conscience?

The call has been answered by some who are willing and eager to throw away their old prejudices but their efforts have been met with resistance and attack. When the Earth is crying for help in so many directions, how can one think of Space? Yet, for one breathless moment, the first time in recorded history, man became Mankind as one footstep descended on the Moon. There must have been something very special in this simple act to unite the hearts and spirits of humanity.

However, in spite of opposition, some of the effects of Apollo are already beginning to be felt and to stir the imagination. Of what do they give promise? - undreamed of opportunities, of course, but, more immediately, an Earth renewed in body and spirit; a pattern for solving Earth's problems, provided that the will of humanity be strong enough; a catalyst for education, replacing fear and ignorance with knowledge and awareness of the probability of the "impossible"; and, most important, the evolution of the idea of the importance and dignity of each and every individual. One human being can make a difference!

INDIVIDUALIZED INSTRUCTION
Introductory Remarks

Five, four, three, two, one ----- LIFT OFF!

You have probably heard this before. However, let us suppose that you have to decide which of these two people, responsible for this event, are more important - the astronaut who flies the mission or the electrician who wires the space ship? How will you decide?

Would you say that the astronaut is more important because he has to do the actual flying? Perhaps you would be right. On the other hand, would you say that the electrician was more important because it was his responsibility to see that the electrical equipment was in perfect order? If it were not, then the space ship and the astronaut might not be able to complete the mission. In that case, those deciding for the electrician would also be right.

Well, how could two people disagree and still both be right? Very easily, especially if the disagreement concerns people and what they do. Of course, the astronaut is important because he flies the mission but the success of his efforts depends on a space-worthy ship. On the other hand, the electrician could put in the most perfect system known to man but, with no one to fly the ship, the perfection would never be known.

The astronaut, the electrician, and hundreds of thousands of other individuals are needed as a team to reach the goal for which they are working. Each and every individual becomes very

important when a job for mankind has to be done. Each individual is important because each has a very special talent to contribute according to his ability and training.

How does the astronaut become what he is and how does the electrician come to do his job so well? They each have to learn what they need to know. Do they both learn in the same way? Probably not. Since they are two different individuals they not only have their own particular talents and abilities but also their particular ways of learning. Perhaps even in school, when they were very young, they each learned how to read and write in ways that were different from each other. As they grew into maturity, their differences still remained, leading one to go into flying and the other into electronics.

Now, what has all this to do with you? Well, you are a very important person because you are an individual having talents and abilities different from any other individual in the world. However, because we are human beings, we all have common steps through which we must go although how we go through these differs. For example, when you first learned how to walk, the way you did it was probably different from any of your brothers or sisters, - in fact, probably different from any other baby in the world. In the same way, when and how you learned to talk, to read, to write, and to play games with each other was different from any one else.

Even though the "when" and "how" may have been different, you, as an individual, did eventually mature enough to become -4-

to be recognized as a fine, young human being. In all of this, the accent was on the word "learn." The opportunity to learn is a gift which all mankind has. Learning goes on all your life. If learning goes on for the rest of your life, then isn't it important to find out how best you, as a very special person, learns? Did you ever stop to think how you learn anything? Perhaps this year, you may have a chance to find this out for yourself. You will not only be learning about science and how it works but also, more important, you may be able to learn more about yourself and how you work. You are going to sample a type of learning called "Individualized Instruction." What this is and how it will help you will be investigated this year. I hope you find this way of learning helpful. I look forward to knowing you and to helping you discover that special person called YOU.

Now that you have come this far, you are ready to take PRE-TEST I-1. This is not a test of the kind you may have experienced before - it is only a means of getting some information about what you know or think on a particular topic so that we may know where to start our working together. After all, I have no idea about how much you may already know. There is no "mark" with a pre-test. It has nothing to do with your grade so feel free to express yourself honestly.

When you have completed the pre-test, please hand it in and continue with UNIT I, Topic 1: INTRODUCTION TO INDIVIDUALIZED LEARNING. This will give you some idea of how we will worktogether this year. If there is something you don't understand, please feel free to ask me.

TSM

INDIVIDUALIZED LEARNING

Unit 1 Introduction to Individualized Learning

Topic 1 Learning Activity Package (LAP)

OBJECTIVES:

1. To demonstrate your ability to read and understand written material by following instructions given in ACTIVITIES below.

2. To self-test your ability to depend on yourself by handing in FIVE MINUTES BEFORE THE END OF THE PERIOD, any work you have done. You will not be reminded to do so.

3. To show that you can discuss the relationship between LAP and Individualized Learning by taking a self-evaluation test and entering into a group discussion on the matter.

ACTIVITIES:

1. Read a STUDENT GUIDE AS TO WHAT IS CONTAINED IN A LEARNING ACTIVITY PACKAGE

2. Take out your pen or pencil, which you should have every day. If you forgot to bring one today, you may use the pencil provided. BE SURE TO RETURN IT FOR SOME ONE ELSE MAY NEED IT.

3. On WORKSHEET I-I-3, provided for you, list the contents of a LAP and briefly note what each one is supposed to do, This will serve as one example of what you will keep in your notebook.

4. Obtain a VOCABULARY SHEET and list any words which are new to you. Check to see if you have spelled them correctly. Add the meaning next to the word.

5. Obtain an ANSWER SHEET and take the SELF-EVALUATION TEST. This is an example of how you can test yourself on material covered.

6. Mark your own test by listening to the answers on the cassette or by using an answer guide which you may obtain. How to mark the test is given in the answer guide.

7. When you feel that you have done all the activities above to the best of your ability, ask for the post-test on this UNIT. This will serve as an example of whether or not you are ready to go on to the next unit.

8. Discuss the meaning if Individualized Instruction in a class discussion. This class discussion will serve to show how talking it over in a group helps to exchange opinions and clear up matters not understood. Of equal importance will be the realization that discussions are more interesting and worthwhile if you have some knowledge and experience to back up your opinions.

9. ADDITIONAL ACTIVITIES.

UNIT II: OBSERVATION OF THE PHYSICAL WORLD

TOPIC I: Encountering the physical world

OBJECTIVES:

1. Given sets of photographs of the heavenly bodies to list observations of objects in space.

2. To use the metric ruler with which to begin experience with the Metric system in making and noting mathematical evidence for observation.

3. To simulate by experiments in the laboratory some conditions or events occuring in heavenly bodies.

ACTIVITIES:

1. Obtain a copy of Investigation Book #1. Read page 1 and answer the following questions in your notebook:

   A. What is the physical world that surrounds us?
   B. What did people in former times consider important in their environment?
   C. How would you begin an investigation of the physical world?

2. Observe pages two and three of Book 1 showing a scene of New Mexico. To sharpen your observations, answer the following in your notebook:

   A. Where was the sun when the picture was taken?
   B. At what time of day and in what direction was the picture taken?
   C. What objects can you observe in the picture?
   D. Why are these objects visible?
   E. What would this scene be like in another hour?
   F. What evidence of celestial motion would there be in an photograph taken an hour later?

3. On pages 4 and 5 of Book 1 you will find star trails as taken by lapse photography. Locate the constellation Orion, using the picture taken from a celestial atlas of 1729 on page 1. Answer the following questions in your notebook:

   A. How do the positions of stars at the beginning and end of the hour compare?
   B. How does the pattern of stars in Orion at the present time compare with the pattern seen by 18 Century observers?

4. Compare the pictures of the rising moon and the rising sun on pages 6 and 9 with the picture of the star trails. Show your ability to observe by answering the following in your notebook:

   A. What do the three pictures have in common?
   B. In what direction do these objects seem to be moving?
   C. Using the metric ruler, determine the distance traveled by the sun, moon, and stars in one hour. Write the distance in centimeters.

5. Observe the changes in the moon's appearance on pages 10-11 of Book 1. Note your observations in your notebook. Answer the following questions to pinpoint your observations.

   A. What would the moon have looked like on August 19 or 20?
   B. How long does it take for each of the three cycles of changes to take place?
   C. Does the amount of lighted surface appear to change evenly or unevenly over the intervals of time shown? Give examples of observations to support your answer.
   D. What happens to the size of the moon throughout its cycle?

6. Obtain Experiment II-1-6 having to do with the moon's appearance

7. Experiments on the Selenology of the moon. Selenology refers to the story of the moon and its features just as geology refers to the story of the earth and its features.

   A. Atmosphere of the moon and surface temperature
   B. Light reflection
   C. Lunar craters
   D. Lunar origins
   E. Moon-roving vehicles
   F. Weight on the moon

8. Zooming in on the moon: From the Ranger photographs on page 12 through the end of Book 1, list your observations in your notebook.

9. Obtain a copy of THE LUNAR FIRST by Galileo Galilei and read his record of lunar observations made over three hundred years ago. Compare your observations with those made by Galileo. How much more did you observe than he?

10. Obtain a copy of the STORY OF PROJECT APOLLO. Read and make obsetvations in your notebook.

11. Obtain and view filmstrips or slides on the Apollo missions. Note your observations in your notebook.

12. Read chapter 1 in EARTH SCIENCE (Brown, Kemper, and Lewis) and make notes of important points in your notebook.

13. Find other books in the library on space. Hand in a brief report on your findings.

14. Keep a record of some heavenly body through the school year, such as, the rising moon, constellations, such as, the Big Dipper, or any other of your choice.

UNIT II: OBSERVATION OF THE PHYSICAL WORLD

TOPIC 2: Tools of Observation: Mathematics, the language of science

OBJECTIVES:

1. To reinforce the student's use of decimals as pre-requisite to linear measurements in Metric System, needed for experiments.

2. To review the use of the graph for purposes of clarifying observations and data compiled.

ACTIVITIES:

1. Read and perform the exercises given in REMEDIAL UNIT on Calculation with Decimals.

2. Take the Post Test on Calculation with decimals.

3. READ: INTRODUCTION TO METRIC SYSTEM - LINEAR MEASUREMENTS.

4. Using the two rectangles provided (marked "A" and "B"), clock the time it takes to measure the area of each rectangle in both the English and the Metric systems. Tabulate your observations in chart form. Check your answers at the back of the Unit.

5. Obtain a copy of A FIELD GUIDE TO ROCKS AND MINERALS (Bough). Measure the area of this book in both systems. Time the difference. Make a table of your observations. Check your answers with the Answer Sheet provided in the back of the Unit.

6. Obtain a penny. Find its area in both systems, timing the difference in both systems. If you do not remember how to find the area of a cylinder (which the penny is) check your math book. How close did you come to the answer given in the back of the Unit?

(Please see next page)

*7. Make two tables, as follows, in your notebook and fill in the appropriate data. Time yourself, as above. Check your answers.

8. Take the Post-Test on linear measurements in the Metric system.

9. Obtain a copy of TERMS, TABLES, AND SKILLS. Read Chapter 10. Look through Chapters 11 and 12 for examples of graph types.

10. Obtain the data which the class compiled from the observation of Experiment II-1-7 on lunar atmosphere and surface temperature . Graph the data showing time versus temperature on both the "moon" and the "earth." You will have two lines on the same graph, after you have joined the points. Use two different colors to distinguish the moon surface temperature from that of the earth. Hand in your carbon copy of the experiment, including the graph.

*

Inc.	= Ft.	Yd.
1	1/12	1/36
26		
380		
4200		

mm	= cm	m
1	.1	.001
26		
380		
4200		

UNIT II: OBSERVATION OF THE PHYSICAL WORLD

TOPIC 3: The Surface of the Moon

OBJECTIVES:

1. To find analogous features on moon and earth by examination of photographic evidence.

2. To construct a profile of the crater Copernicus

3. To construct a profile of the New Quebec crater in Arizona

4. To determine by experiment the possible formation of craters

5. To develop a system of classification of craters on the moon by observation of photographs and by mapping lunar features.

ACTIVITIES:

1. Review the notes you took on the film, THE EARTH IN CHANGE. In your notebook list how you could use what you observed about changes on the earth's surface to account for features on the moon's surface.

2. Compare the earth and the moon as shown in photographs on the front cover and on pages 1 through 23 of Investigation Book #8. List the similarities and differences between the two bodies in your notebook.

3. Refer to Activity II-1-7-C and review the features of craters. Note the features in your notebook.

4. Read from the Science Series: VOLCANOES
   A STRANGE CRATER IN ARIZONA
   ARIZONA CRATER: THE CASE FOR IMPACT
   THE EARTH BOMBARDED
   THE MOON'S FACE

   Take notes, for future reference, on the information given.

5. Look through Investigation Book #6 for information on changes on the earth's surface. Make a list of these changes in your notebook.

6. Construct a graph of the profile of Copernicus, using distance in km as the X axis and elevation in km as the Y axis. When completed, hand in the graph for evaluation.

UNIT II: OBSERVATION OF THE PHYSICAL WORLD

TOPIC 3: The Surface of the Moon

ACTIVITIES:

7. Take Post Test II-3-7

8. Construct a graph of the profile of the Arizona crater using the same X and Y axis as in #6. Use m instead of km. When completed, hand in for evaluation.

9. Obtain maps for the near and far side of the moon for use in identification of craters.

10. Compare lunar craters on pages 6 through 13 in Investigation Book #8 with Copernicus. List your observations:

ERATOSTHENES	(pp. 7, 11, 13)
STADIUS	(pp. 7, 11, 13)
ARISTOTELES	(p. 8 bottom right)
ARCHIMEDES	(p. 8 bottom left)
ARISTILLUS	(p. 8 to the right of ARCHIMEDES)
KEPLER	(p. 9)

11. View the Apollo missions slides. You may have done this at the beginning of the year but this second viewing may bring out features missed before.

UNIT II: OBSERVATION OF THE PHYSICAL WORLD

TOPIC 4: Sequence of Events (putting objects or events into a logical order to help solve a problem)

OBJECTIVES:

1. Given a list of events, a student should be able to rearrange them in a proper or acceptable time sequence.

2. Given a photograph which displays a swquence of events, a student should be able to determine a logical time sequence.

3. To have the students list the events in the possible history of the moon based on observation of relative ages of craters as determined from photographs and lunar map constructed previously.

ACTIVITIES:

1. Below is a list of events describing the construction of a school room. Determine a logical sequence and rearrange the sentences in your notebook. Number the correct sequence (1,2,)

   a. lights and fixtures installed
   b. desks placed in the room
   c. room painted
   d. electrical wiring system put in
   e. cement flooring of room poured
   f. blackboards attached to walls
   g. windows installed
   h. floor waxed
   i. walls and ceiling put up
   j. floor tiling set
   k. maps, pictures, and other aids put in place

2. Observe the photograph on page 23 of Investigation Book #8 and determine a sequence of events based on the following:

   a. platform
   b. people on platform
   c. gulleys on crater walls
   d. meteorite impact
   e. crater
   f. broken rocks in foreground
   g. vegetation in foreground

   In your notebook, number the correct sequence.

UNIT II: OBSERVATION OF THE PHYSICAL WORLD

TOPIC 4: Sequence of Events

ACTIVITIES: (Continued)

3. Examine the photograph on pages 34 and 35 of Investigation Book #8. List the sequence of events which you think took place to produce this result.

4. Read pp. 50-1 of EARTH SCIENCE (Silber Burdett) on the Principle of Superposition. Look up this principle in other science books, such as, MODERN EARTH SCIENCE and INVESTIGATING THE EARTH. Write out your idea of this principle in your notebook after you have made notes on your readings.

5. Obtain an outline of the Mare Imbrium area. Using pp. 32-4 as reference, add various features to the map which you can recognize, such as, mountains, rims, peaks, rays, etc. Label all features. Use various moon maps available to help you.

   Using your completed outline map of the Mare Imbrium area, do the following and hand in the completed report:

   a. Determine what feature is the youngest, the oldest, and those in between. Support your opinion.

   b. Using colored pencils, color the map according to your determination above. Show the various degrees from youngest to oldest by a legend.

   c. List a brief history of the formation of the Mare Imbrium area. Include the concept of superposition.

6. Read Activity II-4-6 on the evolution of the moon. Compare your results of the formation of the Mare Imbrium with the account of the proposed history of the moon.

   Indicate in your notebook the results of your comparison.

7. Take Post Test II-4-7

8. Read IMPORTANCE OF INFORMATION GAINED FROM THE MOON.

9. Read SUMMARY OF INVESTIGATION IN SPACE: MAN'S VIEW OF THE EARTH.

10. Discuss A MILLION YEARS FROM NOW and FOOLISH IDEAS.

11. Read KEEPING UP TO DATE ON THE MOON

IMPORTANCE OF INFORMATION GAINED FROM MOON

(Excerpts from Dr. M.H. Schmitt, geologist-astronaut: Apollo 17)

Apollo 15 seeks knowledge and understanding.

> "We should remember that Europe's expansion into the New World was originally a search for treasure. Only later did it become a pursuit of political and religious freedom. Yet, had the early explorers not made their voyages, the opportunities for the far more rewarding quest of freedom might never have existed. In much the same way, many throughout the world realize that the exploration of our planet's frontier also holds human benefits beyond those that gave it birth."

Knowledge sought by Apollo missions:

1. Processes that occurred in the earth during the first one to three billion years - an aid to understanding the distribution of various minerals throughout earth's crust.

2. The moon is a "pitted and dusty window into the birth and adolescence of the earth."

3. Effects of the sun on the earth's natural environment ... the amount and changes of radiation and magnetism received from the sun are major molders of our environment and forces for change ...Hidden record of radiation and magnetism are in the layers of the moon.

Chapters in the moon's history from Apollo 15 rocks:

1. Formation of lunar crust: anorthosite fragments lifted with the mountains before the Imbrium basin was filled with lava.

2. Earth and moon probably formed at the same time.

3. Splash from creation of Serenitatis basin rested on area later to become the Apennine Mountains.

4. Imbrium basin formed after Serenitatis, together with rise of Apennines. Ejecta material covered Fra Mauro.

5. Molten basalt poured from beneath the moon and covered basins.

6. Continued meteorite impact reduced hardened basaltic lava into regolith.

IMPORTANCE OF INFORMATION GAINED FROM MOON

(Continued)

7. Layered regolith from continuous meteorite impact contains radiation and magnetic effects of sun on earth and moon: IMPORTANCE OF DAVE SCOTT'S 8 FOOT LUNAR CORE: SOLAR HISTORY

8. Layers of the moon:

   CRUST: 2 layers of igneous rock (basalt and gabbro-like)

   MANTLE: olivine

   CORE: metallic

IF PRESERVATION OF OUR EARTH IS OUR ONLY GOAL, THEN WE MAY BECOME A MUSEUM OF ANCIENT HISTORY. WE NEED TO EXPAND BY EXPLORATION IN ORDER TO BETTER UNDERSTAND THAT WHICH WE ARE PRESERVING.

LEARNING FROM THE MOON

Lee, Chester M., Apollo Mission Director, NASA, Washington, D.C., TODAY'S EDUCATION, January, 1971

1. Age of moon rocks: 3.5 to 4.5 billion years
   Earth's oldest rocks are not as old as the moon's. This may fill in missing information about the Earth.

2. Chemistry of lunar rocks: unusual combination of common minerals: New Minerals also identified.

3. Significant differences between earth's and moon's volcanic materials: high titanium, very low water content
   low potassium compared to earth - although similiar rocks found in volcanic area of U.S. Sweden, Brazil, and Mid-Atlantic Ridge

4. Rocks from Sea of Tranquility: two separate lava flows - 3.7 and 3.9 billion years; soil 4.billion years

5. Rocks from Apollo 12: 3.4 billion years; soil 4.4 billion yrs.

6. Moonquakes last from 20 minutes to several hours in comparison to seconds on Earth at depths of 500 miles.
   Moonquakes take place every 28.4 days, on closest approach to Earth - 20^{o} to 30^{o} bulge produced.
   Epicenter: Fra Mauro region-50 miles from Apollo 14
   Quakes may be source of escaping gases which produce red and orange flashes seen on moon from Earth.

7. Magnetic field stronger on moon than expected, especially near Apollo 12 landing site.

8. Lunar dust has especially good nutrient properties for Earth simple green plants: usual growth of ½ inch increased to 2 inches, as well as improved color.

9. Mirror target set up by Apollo 11 checking theory of movement of continents on Earth as well as "wobbles" in revolution, which may trigger earthquakes.

10. Oxygen extracted from moon rocks at the University of Rome: heating rocks at $1000^{o}C$ in vacuum, such as on moon. Moon colonies possible with oxygen supply there.

LEARNING FROM THE MOON

- 2 -

11. Rocks from Apollo 14: debris from body that made Mare Imbrium - a planetesimal the size of the Island of Cypress

Planetesimal resembles meteorites of the Class IV A irons

Event occurred about 700 million years after formation of moon

Velocity: 2.4 to 6 km/sec (escape velocity from Earth 11.2 km/sec orbital)

Velocity indicates that meteorite may have orbited the Earth until captured by the moon.

GEOLOGY OF APOLLO 15 MOON LANDING SITE

U.S. Geological Survey, report of August 5, 1971 (appearing in ROCKS & MINERALS January, 1972

1. Some of the mare material at the base of the Apennine Mountains appears to be coarse-grained, vesicular basalts (of volcanic origin), some with pa-hoe-hoe like (ropy) surfaces.

2. Some basalts contain abundant crystals of plagioclase feldspar, a mineral composed chiefly of calcium and sodium aluminum silicates. Most of the basalts are vesicular (containing small cavities) with vesicle sizes ranging up 3 inches. Some rocks were described as anorthosite, a coarsely crystalline rock composed mainly of calcium-rich plagioclase feldspar.

3. The mountains around the site have gentle to moderate slopes and rounded outlines. Lineaments, which may be faults or joints, were noted on distant mountain slopes and are well developed on Mt. Hadley.

4. Observations made toward Mt. Hadley disclosed three ledges which appear to be high marks of lava flows.

5. Hadley rille does not appear to be a drainage course. The upper walls of the rille display multiple layering with columnar jointing, suggesting a series of lava flows.

6. Soils range from loose and powdery to fairly cohesive. Some soils are exceptionally soft, the crew leaving boot tracks 4 to 6 inches deep. Clods of glass-cemented soil occur within some small craters.

7. Ray materials consist of fine fragments with abundant coarse fragments of white rock and some blocks of dark glass.

8. The returned samples of lunar material weighed about 171 pounds. (Total from all missions to date: 388 pounds).

ACTIVITY II-4-9

INTRODUCTION TO SPACE EXPLORATION
MAN'S CHANGING VIEW OF THE EARTH

1. Before Copernicus, man saw the earth as the center of the universe. He believed that the earth stood still and everything moved around it.

2. With Copernicus, came the realization that the sun was the center of the universe and that the earth and the planets went around the sun.

3. Before Columbus, it was believed that the earth was flat.

4. After Columbus, it was believed that the earth was round.

5. Before Newton, what kept the planets moving about the sun and what kept man from falling off the earth were a mystery.

6. After Newton and his discovery of the laws of motion and the law of universal gravitation, man began to understand the forces that kept him and the solar system from falling apart.

7. Modern space studies tell us the following:

   a. The earth is rounded but not a perfect circle, being slightly flattened at the north and south poles and bulging at the equator. Before the advent of space photographs, it was believed to be "pear shaped."

   b. The earth is one member of a system called the Solar System. The Solar System is at one edge of the galaxy we call "The Milky Way." Our twin galaxy is Andromeda. There are innumerable galaxies in the universe.

   c. The sun (our star) has tremendous effects on the earth's natural environment through radiation and magnetism. A hidden record of radiation and magnetism are in the layers of the moon.

   d. The earth in the Solar System is part of a whole universal system.

   e. It is conceivable that there may be life (intelligent or otherwise) somewhere in the universe. WE ARE PROBABLY NOT ALONE.

   f. Concerning the importance of space exploration for the Planet Earth, Dr. H. Schmitt, geologist-astronaut for Apollo 17 has stated:

      "If preservation of our earth is our only goal, then we may become a museum of ancient history. We need to better understand that which we are preserving."

8. As man develops, his views of himself and his part in the universe change. What are the views today?

ACTIVITY II-4-10

A MILLION YEARS FROM NOW -
WHAT DIFFERENCE WILL IT MAKE?

You really know how to mess up a creek, don't you?

A million years from now, who will NOTICE ?

Johnny Hart

****

FOOLISH IDEAS

1. The journey of Columbus to the New World
2. Lenses showing "small animals"
3. Electricity from sparks
4. Trains
5. Automobiles
6. Planes
7. Space exploration
8. Control of earth's ecology and environment through space research
9. ONE MANKIND
10. ..... etc.

CAN YOU THINK OF OTHER SUCH"FOOLISH IDEAS ? "

KEEPING UP TO DATE ON THE MOON
January, 1972

1. The moon now believed to have formed from clouds of cold dust and gas 4.6 billion years ago, at the same time as Earth.

2. The energy of accumulating debris was converted to heat and the outer layer became molten. This resulted in chemical fractionation producing plagioclase-rich material.

   The HIGHLANDS are rich in aluminum indicating that the crust of the early moon was rich in feldspar.

3. After the crust cooled, meteorite bombardment produced basins and craters.

4. Radioactivity in lower layers of moon resulted in internal melting and differentiation with basaltic lava extruding and filling the basins.

MATERIALS COMPOSING THE MOON:

1. FELDSPAR-rich HIGHLANDS - ANORTHOSITE found by Apollo 15 /(rare on earth)
2. BASALTS in plains and basins: solidified lava, low in radioactive elements and young in age.

3. KREEP (potassium, rare earth elements, and phosphorus)-highly radioactive.

4. Radioactive URANIUM, THORIUM, POTASSIUM found in Mare Imbrium and Oceanus Procellarum and some on far side of the moon, indicating that meteorite impact must have been very deep.

5. KREEP BASALTS in Highlands-noritic material found by Apollo 12 and 14.

6. Moon's surface:
   ANORTHOSITE (calcium-aluminum silicates) in Highlands
   Iron-rich BASALTS found in eastern maria
   KREEP in Highlands
   PLUTONIUM 244 found by Apollo 14
   Since the half-life is 84 million years, this element is believed to be extinct, therefore, its presence antedates formation of solar system and must have been picked up and trapped by the moon when the solar system formed.
   "GENESIS BEAN" - shaped like lima bean of green glass similar in composition to group of rare meteorites called Howardites-high in iron and magnesium but low in titanium.

   MAY BE THE RAW MATERIAL FROM WHICH THE MOON WAS MADE.-24-

7. THERMAL HISTORY OF MOON:

3.3 billion years ago:	moon steps heating from exterior downward (half-baked"moon)
1 to 1.5 " " :	solid core - 500 km partially molten inner: - 250 solid residue: - 100 olivine-rich, plagioclass rich: 100
50 to 300 million " :	solid - 80 km partially molten-100 olivine + plagioclass(KREEP)-100
recent to 50 million :	solid-900km crystallizing liquid-100

8. WATER ON THE MOON:

Water vapor detected by Suprathermal Ion Dectectors left at Apollo 12 and 14 sites

Discovery of GEOTHITE, a hydrous mineral, forming rust layer which can only be possible by presence of water and iron

9. PRECURSORS OF AMINO ACIDS

Found in small amounts in Apollo 14 samples.
LIFE MAY HAVE STOPPED BECAUSE OF ABSENCE OF WATER ON SURFACE.

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UNIT III: SPACE EXPLORATION FOR ENVIRONMENTAL BENEFIT OF EARTH

TOPIC 1: Importance of the Sun

OBJECTIVES:

1. To enable the student, through experimental data, to focus on the environmental importance of the sun to earth.

2. To have the students quantitatively measure some physical characteristics of the sun, using microcosm to macrocosm techniques.

3. Through the use of data to have the students visualize predictable changes affecting the earth because of the sun.

ACTIVITIES:

1. Read pages 140-150 in INVESTIGATING THE EARTH (ESCP). Answer questions on page 149 and hand in. Perform Activity III-1-1: MEASURING RADIATION - GEIGER COUNTER.

2. Perform the activity on page 147 of INVESTIGATING THE EARTH relating to use of the spectroscope. Obtain Activity III-1-2 and hand in a written report of your experience.

3. Read pages 21-29 of MODERN EARTH SCIENCE. In your notebook draw figure 2-1 (structure of the sun), figure 2-8 (thermo-nuclear reactions), and figure 2-9 (hydrogen-helium reaction).

4. Read pages 533-536 in MODERN EARTH SCIENCE. Draw the figures showing sunlight effects on the atmosphere to be kept in your notebook for reference.

5. Read pages 156-163 in INVESTIGATING THE EARTH. Do the experiment on page 156 (Activity III-1-5-A: Solar Radiation) and hand in written report of the activity.

   Obtain Activity III-1-5-B: Calories from the sun. After doing the experiment, hand in a written report.

6. Read pages 1-7 in INVESTIGATION BOOK #9 on the sun's activity and surface characteristics. Note points of interest, to be recorded in your notebook for class discussion.

7. Read pages 20-21 in INVESTIGATING THE EARTH. Obtain graph paper and plot the information given on page 21. Let the "year" be the X axis and the "sunspot number" the Y axis. Write up your activity, including answers to questions on page 21.

UNIT III: TOPIC 1
Importance of the Sun
- 2 -

8. Read Chapter 12 in EARTH SCIENCE (Silver Burdett): SOLAR ENERGY AND THE ATMOSPHERE. Answer questions in Study Guide on pages 152, 158, and 162 and hand in.

9. Read pages 518-525 in EARTH SCIENCE (Silver Burdett): THE SUN. Answer and hand in Study Guide questions on page 524.

10. Read pages 95-99 in INVESTIGATING THE EARTH on time: THE SUN AS TIME SETTER. Answer the THOUGHT AND DISCUSSION QUESTIONS on page 101, to be used for class discussion.

11. Obtain Activity III-1-11: DO SUNSPOTS AFFECT THE WEATHER? Hand in written report of your experience.

12. Take Post-Test III-1-12.

UNIT III: SPACE EXPLORATION FOR ENVIRONMENTAL BENEFIT OF EARTH

TOPIC 2: Importance of magnetism

OBJECTIVES:

1. To enable the student through experimental data to become alerted to the environmental importance of magnetism to earth.

2. To have the students quantitatively measure some properties of magnetism.

ACTIVITIES:

1. Read pages 521-525 in EARTH SCIENCE (Silver Burdett). Hand in answers to questions in STUDY GUIDE on page 524 and REVIEW AND DISCUSSION QUESTIONS on page 525.

2. Read pages 30-31 in MODERN EARTH SCIENCE. Hand in answers to questions in Group A on page 32.

3. Read pages 120-125 in INVESTIGATING THE EARTH. Perform activity on page 120 and hand in written report. Answer the questions in THOUGHT AND DISCUSSION on page 125 in your notebook, to be kept for future discussion.

4. Make a list of objects which you think can be picked up by a magnet. Bring in (the following day) as many of the objects on your list as you can and test your theory.

5. Obtain Activity III-2-5: EXPERIMENTS IN MAGNETISM. Perform as many as you can, writing up your experience in a report to be handed in.

6. Read pages 501-505 in EARTH SCIENCE (Silver-Burdett). Note pertinent information in your notebook.

7. Obtain Activity III-2-7: HOW THE HEAVENS INFLUENCE OUR LIVES and read the opinion expressed. Write a brief report on your acceptance or rejection of this opinion.

8. Take Post-Test III-2-8.

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UNIT III: SPACE EXPLORATION FOR ENVIRONMENTAL BENEFIT OF EARTH

TOPIC 3: Importance of Monitoring Continental Drift

OBJECTIVES:

1. To focus on the environmental importance to earth of the continental drift, to be tracked from space.

2. To enable the students through experiment gather quantitative data for evaluation of the theory of Plate Tectonics.

ACTIVITIES:

1. Read Chapter 32: DO CONTINENTS DRIFT? in EARTH SCIENCE (Silver-Burdett). Add diagrams on the drift theory to your notebook. Answer and hand in STUDY GUIDE QUESTIONS on page 506 and REVIEW AND DISCUSSION QUESTIONS on page 507.

2. Read pages 364-5 in INVESTIGATING THE EARTH. Obtain a map of the world and cut out the continents. Reproduce the effect shown on page 364 to test the theory. Hand in the results with your comments on your findings.

3. Read pages 225-232 in MODERN EARTH SCIENCE. In your notebook add diagrams illustrating the effects of continental drift.

4. Obtain Activity III-3-4: PLATE TECTONICS. After reading the material, write a report on your opinion of the ideas expressed.

EXTRA:

Find the latest information on PLATE TECTONICS in your library and write a brief research paper on this theory. Include in your paper opinions as to whether or not this theory could be applied to the moon.

5. Take Post-Test III-3-5.

NOTE: If available, see the film, THE RESTLESS EARTH, by Nigel Calder, writer for the British Broadcasting Corporation, shown on Channel 13, New York City.

UNIT III: SPACE EXPLORATION FOR ENVIRONMENTAL BENEFIT OF EARTH

TOPIC 4: Planetary Missions

OBJECTIVES:

1. To investigate the experiments on the moon (ALSEP) showing relationship to earth's environment.

2. To provide experimental data for appreciation of the laws governing the earth and universe and of the impact of constant change.

ACTIVITIES:

1. Read pages 512-17 in EARTH SCIENCE (Silver-Burdett) on the gravitational attraction between earth, moon, and sun. Compare this to the latest information found by the Apollo missions.

2. Read Chapter 34 in EARTH SCIENCE: SPACE. Hand in answers to Study Guide, pages 530, 537, and 542.

3. Read pages 99-101 in INVESTIGATING THE EARTH and draw diagrams in notebook for future reference.

4. Read Chapter 1: THE EARTH IN THE UNIVERSE in MODERN EARTH SCIENCE. Hand in answers to questions in Group B on page 20.

5. Bring in the latest information on the planets as reported in newspapers and other literature. Hand in a summary of your findings to date.

6. Obtain Activity III-4-6: SCALE MODEL OF ORBITS OF MERCURY, VENUS, AND EARTH. Hand in the results of your experience.

7. Obtain Activity III-4-7: CONSTRUCTION OF AN ASTROLABE to measure the altitude of stars (and other objects).

8. Obtain Activity III-4-8: MAKING A STAR MAP.

9. Obtain Activity III-4-9: CONSTRUCTION OF A TIME CONVERTOR TO READ UNIVERSAL TIME.

10. Read Chapter 3: THE SOLAR SYSTEM in MODERN EARTH SCIENCE. Draw diagrams into notebook.

UNITIII: SPACE EXPLORATION FOR ENVIRONMENTAL BENEFIT OF EARTH

TOPIC 4: Planetary Missions

ACTIVITIES: (Continued)

11. Look through pages 8 to the end of INVESTIGATION BOOK #9 and relate to readings done previously.

12. Obtain Activity III-4-12: USING A SEXTANT TO STUDY OBJECTS IN THE SKY.

13. If you have a telescope, organize a star party to find the various features on the moon studied previously. Use the moon map to help in identification of maria, mountains, and craters.

14. Take Post-Test III-4-14.

UNIT IV: EXPLORING THE PLANET EARTH

TOPIC 1: Dimensions of the Earth

OBJECTIVES:

1. To enable the student to continue his knowledge and practice in the use of the Metric System: mass and volume, relating these to density.

2. To develop the student's skill in the use of the unequal arm balance of his own construction.

3. To have the student check his results with the use of standard laboratory balances.

4. To enable the student to put to practice the above skills in determining the mass, volume, and density of the earth.

ACTIVITIES:

1. Review your notes on CALCULATIONS WITH DECIMALS (II-2-2) and INTRODUCTION TO METRIC SYSTEM - LINEAR MEASUREMENTS (II-2-3).

2. Obtain and read Activity IV-1-2: INTRODUCTION TO METRIC SYSTEM - MASS.

3. Obtain Activity IV-1-3: BALANCE ASSEMBLY and two cup buckets to be set at the ends of the balance bar. Adjust the buckets until the bar balances them.

4. Obtain Activity IV-1-4: HOW MAY MASS BE DETERMINED? Perform the activity. Answer all questions and hand in your results. Note that this is the EQUAL ARM BALANCE approach.

5. Obtain Activity IV-1-5: HOW MAY MASS BE DETERMINED - Unequal Arm Balance method. Write up your activity and hand in.

6. Read Activity IV-1-6: INTRODUCTION TO METRIC SYSTEM: VOLUME.

7. Obtain Activity IV-1-7: HOW MAY VOLUME OF AN IRREGULAR OBJECT BE DETERMINED? Unequal Arm Balance method.

8. Take Post-Test IV-1-8 on mass and volume.

9. Obtain Activity IV-1-9: INTRODUCTION TO METRIC SYSTEM - HISTORY AND MODERN DEVELOPMENT OF MEASUREMENT. Take notes on observations and hold for class discussion.

UNIT IV: EXPLORING THE PLANET EARTH

TOPIC 1: Dimensions of the Earth

ACTIVITIES: (Continued)

10. Obtain Activity IV-1-10: SIGNIFICANCE AND MEASUREMENT OF DENSITY. Select the activities proposed and hand in your written reports.

11. Obtain REMEDIAL UNIT: SCIENTIFIC NOTATION to review your ability in this area. Take the Post Test if you feel that you know this.

12. Take Post-Test IV-1-12 on Dimensions.

13. Obtain Activity IV-1-13: MASS, VOLUME, AND DENSITY OF THE EARTH. Hand in your report.

UNIT IV: EXPLORING THE PLANET EARTH

TOPIC 2: A Slice of the Earth: The Grand Canyon

OBJECTIVES:

1. To enable the student, through examination and testing, to learn simple techniques of rock and mineral identification.

2. To develop the story of the earth as evidenced in its rock and fossil record as seen in the Grand Canyon.

3. To relate the information found in the Grand Canyon to the Geological Time Table, in general, and to the physiographic provinces of the United States in particular.

ACTIVITIES:

1. Read Activity IV-2-1: IDENTIFICATION OF ROCKS AND MINERALS. Perform the activities suggested and hand in a report of your results.

2. Obtain a box of class specimens for identification and the Worksheet on which to make your observations. Hand in the summary of your work when completed.

3. Take Post Test IV-2-3: IDENTIFICATION OF UNKNOWN SPECIMENS.

4. Read Activity IV-2-4: ORIGIN OF ROCKS AND MINERALS. Perform the experiments suggested and hand in your results.

5. Obtain Activity IV-2-5: CHRYSTAL MODELS AND CRYSTAL GROWING. Hand in results of experiments performed.

6. Compile a record of current news items pertaining to rocks and minerals. Arrange the items in book form for display.

7. Find and bring into class rocks and minerals from around the school or your home. Identify these and prepare for display.

8. Write a geologic history of your home town or city as shown by the available rock and fossil record.
9. Obtain Activity IV-2-9: EXPLORING A SLICE OF THE EARTH. Perform the activities suggested and hand in your results.
10. Take Post-Test IV-2-10: IMPORTANCE OF THE GRAND CANYON.
11. Obtain a map and guide to the physiographic provinces of the United States. Using different colors, fill in the various rock and mineral structures. Hand in the map.
12. Using the Geological Time Chart, list the stages through which the United States developed geologically to reach its present state. Hand in your report.

UNIT IV: EXPLORING THE PLANET EARTH

TOPIC 3: The Everchanging Surface of the Earth

OBJECTIVES:

1. To have the students observe and experiment with the concept that running water affects the earth by different processes including such as hydraulic action, melting, dissolving, and abrasion.

2. To enable the student to predict change by observing, recording, and analyzing data.

3. To relate the everchanging surface of the Earth to the unifying theory of Plate Tectonics, previously studied.

ACTIVITIES:

1. Obtain Activity IV-3-1: WATER, THE UNCOMMON COMMON SUBSTANCE. Note basic ideas in your notebook.

2. Perform Experiment IV-3-2: HARD WATER - SOFT WATER. Hand in report of your experience.

3. Perform Experiment IV-3-3: DISTILLATION OF WATER. Hand in results of your observations.

4. Perform Experiment IV-3-4: STALACTITES AND STALAGMITES. Write up the experience and hand in.

5. Perform activity IV-3-5: SOLUTIONS. Hand in report of activity.

6. Obtain and perform Experiment IV-3-4: WATER EXERTS PRESSURE. Write out and hand in the report.

7. Determine the chemical nature of water by performing Experiment IV-3-7. Hand in your report.

8. Obtain and perform Activity IV-3-8: OCEAN CURRENTS. Write up your experience.

9. Perform Activity IV-3-9 as a cooperative class experience: WEARING DOWN OF ROCKS BY ABRASION. Write up the experience after data from the class has been recorded.

UNIT IV: EXPLORING THE PLANET EARTH

TOPIC 3: The Everchanging Surface of the Earth

ACTIVITIES: (Continued)

10. Take Post-Test IV-3-10: WATER.

11. Obtain Activity IV-3-11: VOLCANIC PLOT. Hand in your results.

12. Perform Activity IV-3-12: LOCATING THE EPICENTER.

13. Obtain Activity IV-3-12: FORCES ACTING ON THE EARTH'S CRUST.

14. Review the theory of Plate Tectonics. Write a report relating this theory to the changing surface of the Earth. Include in your writing consideration as to whether or not this theory could apply to what you learned about the moon. Present the report for class discussion.

APPENDIX A
UNIT: REMEDIAL

TOPIC: Calculation with decimals

OBJECTIVES:

1. To enable the student to make meaningful observations in science through the use of mathematics.

2. To refresh and reinforce the student's use of decimals in problems involving addition, subtraction, multiplication, and division.

ACTIVITIES:

1. Addition and subtraction

When adding with decimal numbers it is important first to make sure the decimal points all line up in a column. Then you simply add as usual. The decimal point in the answer is in the same column as the numbers above. For example, add the following numbers: 5.2, 6.14, 91.368, and 17.4. Be sure to line up the numbers properly. Your column should look like the following:

```
   5 . 2
   6 . 1 4
 9 1 . 3 6 8
 1 7 . 4
-----------
 1 2 0 . 1 0 8
```

When subtracting, you do exactly the same thing - putting numbers and decimals in proper columns - but this time substract rather than add.

If you think you now understand, complete the following problems in your notebook. Check the answers by looking at the Answer Sheet at the end of the Unit.

ADD THE FOLLOWING NUMBERS:

A. 4.3, 6.273, 173.504

B. 0.007, 5.01, 6.049, 2.3

C. 3.9, 5.04943, 2.67

D. 16.42, 897.463, 8.0004

TOPIC: Calculation with decimals

ACTIVITIES:

1. SUBTRACT THE FOLLOWING NUMBERS:

   E. 14.73 - 9.6

   F. 742.04 - 16.73

   G. 7.46932 - 2.24

   H. 3.407 - 2.3

   I. 74.2 - 67.354

2. Multiplication

   Multiply the numbers as usual just as if the decimal points were not there.

   Count the number of places there are to the right of the decimal in each number.

   Add the number of decimal places.

   In the answer, begin at the number on the right and count back to the left the number of decimal places found in #3.

   For example, in multiplying 2.7 X 3.2:

$$\begin{array}{rll} & 2.7 & \text{(1 decimal place)} \\ \times & 3.2 & \text{(1 decimal place)} \\ & 54 & \\ & 81 & \\ & 8.64 & \text{(2 decimal places needed)} \end{array}$$

$$\underbrace{8\,6\,4}_{2\text{-}1} = 8.64$$

MULTIPLY THE FOLLOWING NUMBERS in your notebook if you think you now understand. Check the answers by looking at the Answer Sheet at the end of the Unit.

TOPIC: Calculation with decimals

A. 5.5 X 2.3

B. 3.82 X 1.3

C. 5.004 X .001

D. 23.42 X .25

E. 7.03 X 6.7

F. 47.1 X 3.22

G. .33 X .44

3. Division

For dividing with decimals, follow the steps below:

Determine which is the divisor and which the dividend --

Quotient
Divisor/ Dividend

Count the number of places there are to the right of the decimal in the divisor

3.24/ 9.73 (2 places)

Move the decimal point in the divisor to the right that (2) number of places

3.24/ 9.72 = 324/ 9.72

Find the decimal point in the dividend and move the decimal to the right the same number of places as you did the divisor

324/ 9.72, = 324/ 972

Move the decimal up into the quotient section directly above the new position in the dividend:

324/ 972.

Now divide, making sure the quotient numbers are placed in their proper places

3.0
324/ 972.0
972
0 0

UNIT: REMEDIAL

TOPIC: Calculation with decimals

Work out the following in your notebook. Check answers by looking at the Answer Sheet at the end of the Unit.

DIVIDE THE FOLLOWING. Please note that ÷ means divided by.

A. 62.7 ÷ 3.4

B. 6.248 ÷ .2

C. 3.624 ÷ 3

D. 396.4 ÷ 2.4

E. .5226 ÷ .13

F. .549 ÷ .9

ANSWER SHEET

UNIT: REMEDIAL
TOPIC: Calculation with Decimals

1. A. 184.077
   B
   B. 13.366
   C. 11.61943
   D. 921.8834
   E. 5.13
   F. 725.31
   G. 5.22932
   H. 1.107
   I. 6.846

2. A. 12.65
   B. 4.966
   C. .005004
   D. 5.8550
   E. 47.101
   F. 151.662
   G. .1452

3. A. 18.4
   B. 31.24
   C. 1.208
   D. 165.2
   E. 4.02
   F. .61

APPENDIX B
UNIT: REMEDIAL

TOPIC: Scientific Notation

OBJECTIVES:

1. To enable the student to write numbers in standard scientific notation as an aid to handling very large and very small numbers in science.

2. To refresh and reinforce the student's skill in adding, subtracting, multiplying, and dividing astronomical and atomic figures using scientific notation.

ACTIVITIES:

1. In order to write numbers in scientific notation, it is important to learn how to express powers of ten. Every number may be expressed as the product of two numbers:

   (figures given in the problem) X (power of ten)

   Copy the following set into your notebook. Count the places determining the power of ten:

1,000,000,000,000 .....1 X 10^{12} .....TERA

1,000,000,000 .....1 X 10^{9} .....GIGA

1,000,000 .....1 X 10^{6} .....MEGA

1,000 .....1 X 10^{3} .....KILO

100 .....1 X 10^{2} .....MECTO

10 .....1 X 10^{1} .....DEKA

1 .....1 X 10^{0} .....

0.1 .....1 X 10^{-1} .....DECI

0.01 .....1 X 10^{-2} .....CENTI

0.001 .....1 X 10^{-3} .....MILLI

0.000.001 .....1 X 10^{-6} .....MICRO

0.000.000.001 ..... 1 X 10^{-9} .....NANO

0.000,000,000,001 ..... 1 X 10^{-12} .....PICO

TOPIC: Scientific Notation

2. Another way of expressing scientific notation is as follows:

10^{-5}	10^{-4}	10^{-3}	10^{-1}	10^{0}	10^{1}	10^{3}	10^{4}	10^{5}
.00001	.0001	.001	.1	1	10	1000	10000	100000
1 /		1 /				/		/
10X10X10X10X10		10X10X10				(10X10X10)		(10X10X10X10X10)

In your notebook, copy the powers of ten heading but including the missing power.

Substituting "5" for the "1" under the power of 10^{0}, enter the proper figures. Check your answer with the Answer Sheet.

3. Scientific notation may be looked at as a "shorthand" or time saver where large numbers are concerned. For example,

7,000,000
may be written: 7×10^{6}

This is a product of two factors - 7 is one factor and the other 10^{0} which is a power of 10. In counting the number of places to determine the power of ten, you probably realized that "7" was the significant number and that the zeros served to place the decimal point, understood after the last zero.

Generally speaking, all digits that make up a number, except zeros that designate ten, hundreds, thousands, etc., are significant figures. For example, in:

375,000

"375" are significant since they identify that particular number. In scientific notation, it would be written as:

3.75×10^{5}

Some other examples are:

$83.000 = 8.3 \times 10^{4}$

$845,000,000,000 = 8.45 \times 10^{11}$

$0.0716 = 7.16 \times 10^{-2}$

$0.000,000,342 = 3.42 \times 10^{-7}$

TOPIC: Scientific Notation

In each case, you put a decimal after the first significant figure and then count the number of places TO THE RIGHT if the number is more than 1 and TO THE LEFT if the number is less than 1.

TURN TO PAGE 16 in TERMS, TABLES AND SKILLS (Bobby J. Woodruff). Work out examples 1-15 in your notebook. Check your answers on page 150. Redo those problems which you found incorrect.

4. Problems in science using scientific notation

A. Light year

A "light year" is the distance traveled by light in one earth year.

Light travels at a speed of 186,000 mi/sec (English)
30,000,000,000 cm/sec (Metric)

In your notebook, calculate a light year in cm. Use the following pattern to aid you in your calculations:

30,000,000,000 cm/sec
_____ X 60 sec (60 sec = 1 min)

..... cm/min
_____ X 60 min (60 min = 1 hr)

..... cm/hr
_____ X 24 hr (24 hr = 1 day)

.....
_____ X 365 days (365 days = 1 yr)

Answer: ..... cm/year (light year)

Repeat the above problem but this time use scientific notation. Check your answers with Answer Sheet at the back of the Unit.

B. What is the mass of a PROTON? (How much matter exists in a proton?)

0,000 000 000 000 000 000 000 001 67 gm

Write this figure into your notebook and then rewrite it in scientific notation. Check your answer with the Answer Sheet in back of the Unit.

UNIT: REMEDIAL

TOPIC: Scientific Notation

C. What is the mass of an ELECTRON? (How much matter exists in an electron?)

0,000 000 000 000 000 000 000 000 000 91 gm

Write this figure into your notebook, properly labeled, and then rewrite it in scientific notation. Check your answer with the Answer Sheet in back of the Unit.

IF YOU FOUND THAT YOUR ARE STILL HAVING TROUBLE WITH SCIENTIFIC NOTATION, TRY THE FOLLOWING ACTIVITIES. IF YOU WERE ABLE TO DO ALL THE PROBLEMS GIVEN SO FAR WITHOUT DIFFICULTY, YOU MAY SKIP THIS SECTION AND GO ON TO ACTIVITY 8.

* *

5. In scientific notation we want to change the way the number appears and not its value. We must adjust the answer so that it really has the same value as before.

To change the appearance and not the value, we move the decimal point and then adjust the final result by multiplying by 10, 100,1000 or 1/10, 1/100, 1/1000 depending on which way we move the decimal and how many places.

In scientific notation we move the decimal point until it is placed after the greatest place value number. For example:

7984 is the same as 798.4×10 (decimal moved 1 place)

or

79.84×10^2 $(79.84 \times 10 \times 10)$ decimal moved 2 places

or

7.984×10^3 $(7.984 \times 10 \times 10 \times 10)$ decimal moved 3 places

Since "7" has the greatest place value, 7.984×10^3 would be the correct form in scientific notation.

DO THE FOLLOWING IN YOUR NOTEBOOK:

Change 768 to scientific form by

a. putting the decimal after the greatest place value number:

7. 6 8 (decimal moved 2 places)

TOPIC: Scientific Notation

b. adjusting this change by multiplying 7.68 X 10 X 10

c. writing the correct form as 7.68×10^{-2}

Change 78,959.5 to scientific form by:

a. putting the decimal after the greatest place value number:
7. 8 9 5 9 5 (decimal moved 4 places)

b. adjusting this change by multiplying 7.89595 X 10 X 10 X 10 X 10 X 10

c. correct form: 7.89595×10^{4}

6. Complete the following chart in your notebook and check the answers in the Answer Sheet in the back of the Unit:

NUMBER	EXPANDED SCIENTIFIC FORM	SCIENTIFIC FORM
384	3.84 X 10 X 10	3.84×10^{2}
55.4		
76.37		
237		
486.2		
963.22		
1374		
7542.6		
6384.57		
11,463		
16,824.5		
84,923.76		
246,892		
861,394.2		
1,830.402		
2,560,000		
40,004.000		
98,000,000		
476,000,000		
3,967,000,000		

After having completed this chart, you may be better able to understand why scientists feel that SCIENTIFIC NOTATION is a "shorthand" for writing large numbers.

UNIT: REMEDIAL

TOPIC: Scientific Notation

7. So far the numbers considered have been larger than "one". It is just as easy to work with numbers that are less than one. For example, to change

.69

to the expanded scientific form, move the decimal after the first significant figure:

6.9 (one place)

and multiply by 1/10 this time, instead of by 10, since the number .69 is less than one:

6.9 X 1/10

In the same way, the number:

.00076 becomes 7.6 (four places)

7.6 X 1/10 X 1/10 X 1/10 X 1/10

In scientific notation:

$6.9 \times 1/10 = 6.9 \times 10^{-1}$

$7.6 \times 1/10 \times 1/10 \times 1/10 \times 1/10 = 7.6 \times 10^{-4}$

COMPLETE THE FOLLOWING CHART in your notebook and check the answers in the Answer Sheet in the back of the Unit:

NUMBER	EXPANDED SCIENTIFIC FORM	SCIENTIFIC NOTATION
.65	6.5 X 1/10	6.5×10^{-1}
.7		
.06		
.082		
.080		
.002		
.0006		
.0034		
.01234		
.00005		
.0105		
.0000008		
.67432		
.00574		
.00000001 .073		

TOPIC: Scientific Notation

8. Scientific Notation helps the scientist to handle large numbers more easily. You may have noticed that, in some of the examples used, the number of decimal places was also quite large. In order to further simplify the handling of large numbers, unlimited significant figures may be rounded off.

If the extra digits are less than 5, the preceding figure is not changed:

13.462 13.46

If the digit to be dropped is greater than 5, the last figure kept is increased by 1:

13.468 13.47

If the digit to be dropped is exactly 5, round off so that the retained figure is an even number:

13.465 13.46

13.475 13.48

In our work, we shall use no more than TWO decimal places which may be further rounded off to one place.

TO REFRESH YOUR MEMORY OF SIGNIFICANT FIGURES IN SCIENTIFIC NOTATION AND THE ROUNDING OFF OF THE FIGURES, do the excercises on page 19 of TERMS, TABLES, AND SKILLS. Check your answers at the back of the book. Rewrite in scientific notation.

Round off each of the answers. Check your final answer at the end of the Unit.

9. SCIENTIFIC NOTATION IN ADDITION AND SUBTRACTION

In order to add or subtract numbers using scientific notation, it is important and necessary to have the exponents of 10 the same. (You may recall that when you add or subtract the items have to be similar - when you are adding "apples" you can't put in a few oranges.)

For example, in order to add the following:

$$\begin{array}{r} 2.6 \times 10^{3} \\ + \ 6.2 \times 10^{4} \\ \underline{5.2 \times 10^{1}} \end{array}$$

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the exponents of ten must first be made the same. It does not matter which power you choose but the final answer must be in the correct scientific notation form.

$2.6 \times 10^3 = 2.6 \times 10^3$ or $.26 \times 10^4$

$6.2 \times 10^4 = 62.0 \times 10^3$ 6.2×10^4

$5.2 \times 10^1 = .052 \times 10^3$ $.0052 \times 10^4$

64.652×10^3 6.4652×10^4

6.4652×10^4

Round off, we get 6.5×10^4

PROBLEM: In your notebook, work out the addition of the following:

a. 1.72×10^2

$+ \quad 0.15 \times 10^3$

627.1×10^4

Be sure to write out the answer in final scientific notation form and to round off the figures. Check your answer in the Answer Sheet at the back of the Unit.

Do the same as above for the following:

b. 2.6×10^{-4}

$+ \quad 3.4 \times 10^{-2}$

Check your answer as above.

PROBLEM: In your notebook, work out the subtraction of the following:

c. 3.93×10^7

$- \quad 7.81 \times 10^6$

d. 2.9×10^{-4}

$- \quad 6.4 \times 10^{-5}$

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10. SCIENTIFIC NOTATION IN MULTIPLICATION AND DIVISION

In order to multiply or divide numbers using scientific notation:

Multiply or divide the significant figures just as you would in any other problem with decimals

BUT

Add the exponents when multiplying

Subtract the exponents when dividing

For example:

$$\begin{array}{r} 3.2 \times 10^{3} \\ \times\ 1.5 \times 10^{2} \\ \hline 160 \\ 32 \\ \hline 4.80 \times 10^{3+2} \end{array} = 4.8 \times 10^{5}$$

Another example would be:

$$\begin{array}{r} 3.2 \times 10^{-3} \\ \times\ 1.5 \times 10^{2} \\ \hline 160 \\ 32 \\ \hline 4.80 \times 10^{-3+2} \end{array} = 4.8 \times 10^{-1}$$

IN YOUR NOTEBOOK, work out the following multiplication problems:

a. $(3.2 \times 10^{-3}) \times (1.5 \times 10^{-2})$

b. $(2.0 \times 10^{8}) \times (8.0 \times 10^{2})$

c. (8,200) X (510) BE SURE TO REWRITE IN SCIENTIFIC NOTATION

d. (910) X (0.00030)

e. $(7.2 \times 10^{4})\ (6.3 \times 10^{7})$

f. $(6.3 \times 10^{5})\ (1.2 \times 10^{4})$

g. $(2.2 \times 10^{4})\ (4.44 \times 10^{1})$

h. $(8.74 \times 10^{2})\ (4.1 \times 10^{2})$

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j. $(2.5 \times 10^{7})\ (1.5 \times 10^{-2})$

k. $(3.4 \times 10^{2})\ (5.2 \times 10^{-3})$

l. $(2.4 \times 10^{-2})\ (2.4 \times 10^{-6})$

m. $(1 \times 10^{5})\ (2 \times 10^{7})$

n. $(3 \times 10^{-11})\ (3 \times 12^{-12})$

Check your answers in the Answer Sheet at the end of the Unit.

- - - - - - - - - - - -

IN YOUR NOTEBOOK, work out the following division problems:

Remember that although the significant numbers are divided as usual, the EXPONENTS are SUBTRACTED as for example:

$$\frac{6.6 \times 10^{4}}{2.2 \times 10^{2}} = 3 \times 10^{(4)-(2)} = 3 \times 10^{2}$$

$$\frac{8 \times 10^{2}}{4 \times 10^{4}} = 2 \times 10^{(2)-(-4)} = 2 \times 10^{-2}$$

$$\frac{6 \times 10^{-4}}{3 \times 10^{5}} = 2 \times 10\ (-4) - (+5) = 2 \times 10^{-9}$$

$$\frac{6 \times 10^{5}}{3 \times 10^{-2}} = 2 \times 10^{(+5)-(-2)} = 2 \times 10^{7}$$

o. $\frac{8.4 \times 10^{7}}{2.1 \times 10^{-4}}$

p. $\frac{8.4 \times 10^{-7}}{2.1 \times 10^{-4}}$

q. $\frac{2.73 \times 10^{4}}{9.1 \times 10^{-2}}$

r. $2.6 \times 10^{4} \div 1.3 \times 10^{2}$

s. $3.8 \times 10^{5} \div 2 \times 10^{-2}$

t. $1.8 \times 10^{7} \div 9 \times 10^{6}$

u. $8 \times 10^{3} \div 4 \times 10^{1}$

v. $8 \times 10^{-2} \div 8 \times 10^{3}$

w. $6 \times 10^{4} \div 2 \times 10^{-7}$

x. $5 \times 10^{6} \div 1 \times 10^{5}$

y. $6.52 \times 10^{5} \div 4 \times 10^{2}$

z. $1.344 \times 10^{8} \div 6 \times 10^{1}$

APPENDIX B

ANSWER SHEET

UNIT: Remedial

TOPIC: Scientific Notation

2.

10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}	10^{2}
.00005	.0005	.005	.05	.5	5	50	500

10^{3}	10^{4}	10^{5}
5000	50000	5000000

3. (See pg. 150 in TERMS, TABLES, AND SKILLS)

4. A. 946,080,000,000,000,000 cm/yr

9.4608×10^{17}

B. 1.67×10^{-24} gm

C. 9.1×10^{-28}

6.

EXPANDED	SCIENTIFIC NOTATION
5.54 X 10	5.54×10^{1}
7.637 X 10	7.637×10^{1}
2.37 X 10 X 10	2.37×10^{2}
4.862 X 10 X 10	4.862×10^{2}
9.6322 X 10 X 10	9.6322×10^{2}
1.374 X 10 X 10 X 10	1.374×10^{3}
7.5426 X 10 X 10 X 10	7.5426×10^{3}
6.38457 X 10 X 10 X 10	6.38457×10^{3}
1.1463 X 10 X 10 X 10 X10	1.1463×10^{4}
1.68245 X 10 X 10 X10 X 10	1.68245×10^{4}
8.492376 X 10 X 10 X 10 X 10	8.492376×10^{4}
2.46892 X 10 X 10 X 10 X 10 X 10	2.46892×10^{5}
8.613942 X 10 X 10 X10 X10 X 10	8.613942×10^{5}
1.830402 X 10 X 10 X 10	1.830420×10^{3}

APPENDIX B

ANSWER SHEET
UNIT: Remedial
TOPIC: Scientific Notation

EXPANDED	SCIENTIFIC NOTATION
2.56 X 10 X 10 X 10 X 10 X 10 X 10	2.56×10^{6}
4.0004 X 10 X 10 X 10 X 10 X 10 X 10 X 10	4.004×10^{7}
9.8 X 10 X 10 X 10 X 10 X 10 X 10 X 10	9.8×10^{7}
4.76 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10	4.76×10^{8}
3.967X10 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10	3.967×10^{9}

7.

EXPANDED	SCIENTIFIC NOTATION
7 X 1/10	7×10^{-1}
6 X 1/10 X 1/10	6×10^{-2}
8.2 X 1/10 X 1/10	8.2×10^{-2}
8.0 X 1/10 X 1/10	8.0×10^{-2}
2 X 1/10 X 1/10 X 1/10	2×10^{-3}
6 X 1/10 X 1/10 X 1/10 X 1/10	6×10^{-4}
3.4 X 1/10 X 1/10 X 1/10	3.4×10^{-3}
1.23 X 1/10 X 1/10	1.23×10^{-2}
5 X 1/10 X 1/10 X 1/10 X 1/10 X 1/10	5×10^{-5}
8 X 1/10 X 1/10 X 1/10 X 1/10 X 1/10 X 1/10X1/10	8×10^{-7}
6.7432 X 1/10	6.7432×10^{-1}
5.74 X 1/10 X 1/10 X 1/10	5.74×10^{-3}
1 X1/10X1/10X1/10X1/10X1/10X1/10X1/10	1×10^{-8}
7.3 X 1/10 X 1/10	7.3×10^{-2}

8.	(1)	2.9625×10^{4}	3×10^{4}
	(2)	2.006×10^{-2}	2.01×10^{-2}
	(3)	3.017×10^{0}	3.02×10^{0}
	(4)	1.0082×10^{1}	1.01×10^{1}
	(5)	1.1×10^{-4}	1.1×10^{-4}
	(6)	9×10^{-6}	9×10^{-6}
	(7)	3.000009×10^{0}	3×10^{0}
	(8)	2.690×10^{3}	2.7×10^{3}
	(9)	6.50×10^{0}	6.5×10^{0}
	(10)	9×10^{2}	9×10^{2}
	(11)	6.0013×10^{4}	6×10^{4}
	(12)	2.1040×10^{1}	2.1×10^{1}
	(13)	7.01×10^{6}	7.01×10^{6}
	(14)	2.00×10^{3}	2×10^{3}
	(15)	9.060×10^{5}	9.1×10^{5}

9. a. 6.3×10^{6}
   b. 3.43×10^{-2}
   c. 4.7×10^{7}
   d. 2.3×10^{-4}

10. a. 4.8×10^{-5}
    b. 1.6×10^{11}
    c. 4.2×10^{6}
    d. 2.7×10^{-1}
    e. 4.5×10^{12}
    j. 3.8×10^{5}
    k. 1.8×10^{0}
    l. 5.8×10^{-8}
    m. 2×10^{12}
    n. 9×10^{-23}
    r. 2×10^{2}
    s. 1.9×10^{7}
    t. 2×10^{0}
    u. 2×10^{2}
    v. 1×10^{-5}